

21. (amended) The photodetector of claim 15 wherein each hole transporting layer comprises copper phthalocyanine (CuPc) and each electron transporting layer comprises 3,4,9,10-perylenetetracarboxylic-bis-benzimidazole (PTCBI).

22. (amended) The photodetector of claim 15 wherein the plurality of pairs is at least 5 pairs.

23. (amended) The photodetector of claim 15 wherein the plurality of pairs is at least 10 pairs.

24. (amended) The photodetector of claim 15 wherein the exciton blocking layer is disposed between the anode and the plurality of pairs and a second exciton blocking layer is disposed between the cathode and the plurality of pairs.

25. (new) An organic photosensitive optoelectronic device comprising:
two electrodes in superposed relation;
a hole transport layer between the two electrodes, the hole transport layer formed of a first photoconductive organic semiconductor material;
an electron transport layer between the two electrodes and adjacent to the hole transport layer, the electron transport layer formed of a second photoconductive organic semiconductor material; and
at least one exciton blocking layer between the two electrodes and adjacent to at least one of the two electrodes, wherein the thickness of the at least one exciton blocking layer is on the order of, or less than the exciton diffusion length.

REMARKS

Introduction

Claims 1 - 24 are pending in the present application. In response to the Office Action mailed August 15, 2001, Applicants have amended the specification and the claims in order to clarify the subject matter of the present invention. This amendment is supported by the Applicants' original disclosure and does not introduce any new matter into the present

application. Reconsideration of the subject patent application in light of the present amendment and remarks, which have been made to place this application in condition for allowance, is respectfully requested.

Response to Examiner's Objections to Specification

In the Office Action mailed August 15, 2001, the Examiner has objected to the specification because of various informalities. The Examiner requested clarification and amendment of Figure 1 to include the legend --Prior Art-- because only that which is old is illustrated, citing to MPEP § 608.02(g). In response, Applicants have amended Figure 1 to include "Prior Art" as a legend.

The Examiner has also requested replacement of the docket number 10644/50101 with the application serial number on page 30, lines 14-15. Applicants have accordingly amended the specification on page 30 at lines 14-15 by replacing "Attorney docket number 10644/50501 ("50501 Application")" with "No. 09/449,800 ("800 Application")."

Response to Examiner's Rejections of Claims under 35 U.S.C. 112, 2nd paragraph

The Examiner has rejected Claims 5-7 and 11-24 under 35 U.S.C. 112, 2nd paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. First, the Examiner objects that the meaning of the abbreviations "PTCBI", "CuPc", "BCP", "m-MTDATA", and "PEDOT" are not given in the claims. Applicants have amended the claims to clearly identify these materials. These abbreviations are defined in the Specification as follows. The meanings of "CuPc" or copper phthalocyanine, and "PTCBI" or 3,4,9,10-perylenetetracarboxylic-bis-benzimidazole, are provided on page 4, lines 16-17 of the Specification. The definition of "BCP," also called bathocuproine, and identified as 2,9-dimethyl-4,7-diphenyl-1,10-phenanthroline, is provided on page 14 at lines 18-19 of the Specification. Finally, the terms "m-MDATA" and "PEDOT" are defined on page 15 at lines 14-15 of the Specification: m-MTDATA represents 4,4',4''-tris{N,-(3-methylphenyl)-N-phenylamino}triphenylamine and PEDOT represents polyethylene dioxythiophene.

Second, the Examiner alleges that claims 5 and 20 are indefinite due to the

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requirement for "substantial spectral sensitivity"; specifically, the Examiner finds the term "substantial" a relative term that provides insufficient guidance to determine the metes and bounds of "substantial spectral sensitivity." For clarification, Applicants have amended claim 5 and claim 20 to delete the term "substantial."

Third, the Examiner alleges that claim 11 and its dependent claims are incomplete because the only component of the at least one subcell explicitly set forth in claim 11 is an exciton blocking layer. Applicants have amended claim 11 to clarify the components of the at least one subcell. Applicants have also amended claims 12-24 to correct typographical and grammatical errors pointed out by the Examiner, and to correct problems regarding antecedent basis contained therein.

Response to Examiner's Rejections of Claims under 35 U.S.C. § 102(b)

The Examiner has rejected claims 1-5 as being anticipated by either U.S. Patent 5,201,961 ("Yoshikawa et al.") or U.S. Patent 5,350,459 ("Suzuki et al."). The Examiner has rejected Claims 1, 3 and 5 as being anticipated by Yoshikawa et al. The Examiner contends that "it is reasonable to expect that at least some of Yoshikawa's examples provide devices that inherently meet the limitations of claim 1, 3 and 5," though no mention of an exciton blocking layer in the device structure is provided. The Examiner has also rejected claims 1-5 as being anticipated by Suzuki et al. The Examiner again contends that "it is reasonable to expect ... that at least some of the examples... [in Suzuki et al.] provide devices that inherently meet the limitations of present claims 1-5...."

The burden on the Examiner is described in *Ex parte Levy*, 17 USPQ2d 1461, 1464 (Bd. Pat. App. & Int'l 1990) and is recited in MPEP § 2112: "In relying upon the theory of inherency, the examiner must provide a basis in fact and/or technical reasoning to reasonably support the determination that the allegedly inherent characteristic necessarily flows from the teachings of the applied prior art." Applicants respectfully submit that the Examiner has not met her burden of proof in alleging that Yoshikawa et al. and Suzuki et al. inherently anticipate the present invention.

In regard to the Suzuki et al. reference, the Examiner cites no example or teaching-- no specific technical proof or reasoning -- to support her contention that "at least some of the

examples” in Suzuki et al. inherently meet the limitations of present claims 1-5. Therefore, the Examiner has failed to “provide a basis in fact and/or technical reasoning to reasonably support the determination that the allegedly inherent characteristic necessarily flows from the teachings of the applied prior art.”

In addition, the Examiner cites only one example in Yoshikawa et al. that has a layer of quinacridone that allegedly inherently functions as an exciton blocking layer (“EBL”). However, the Examiner has failed to show that “the allegedly inherent characteristic necessarily flows from the teachings of” Yoshikawa et al. In reaching the conclusion that quinacridone inherently functions as an EBL, the Examiner first assumed that the quinacridone of Example 5 is non-substituted quinacridone, even though the specification cites 20 different types of quinacridone. Second, the Examiner states that non-substituted quinacridone emits a peak wavelength of about 540 nm, but cites no reference in support of this, which corresponds to a bandgap of about 2.3 eV. Third, using the LUMO-HOMO separation value of approximately 1.7 eV of adjacent layer CuPc provided in the present specification, the Examiner concludes that “[s]ince quinacridone has a higher bandgap than copper phthalocyanine, the layer of quinacridone inherently functions as an exciton blocking layer in the device structure....”

The Examiner, therefore, has had to look outside “the teachings of the applied prior art” to support her determination that the prior art inherently anticipates an exciton blocking layer. The Examiner has cited nothing in Yoshikawa et al. that “reasonably supports the determination” that the device of Yoshikawa et al. inherently includes an exciton blocking layer. “To establish inherency, the extrinsic evidence ‘must make clear that the missing descriptive matter is necessarily present in the thing described in the reference, and that it would be so recognized by persons of ordinary skill.’” *In re Robertson*, 169 F.3d 743, 745 (Fed. Cir. 1999); *see also* MPEP §2112. On page 11, line 2 of the present specification, Applicants provide that “an EBL is characterized by its ability to prevent the diffusion of excitons from an adjacent organic layer into or across the EBL.” Further, on page 13, line 8, the specification sets forth that “the EBLs comprising the present invention derive their exciton blocking property from having a LUMO-HOMO energy gap substantially larger than that of the adjacent organic semiconductor from which excitons are being blocked.” Finally,

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at line 20 of page 13, the specification clearly states that “the exciton blocking nature of a material is not an intrinsic property” and that whether or not the layer functions as an EBL “depends upon the relative HOMO and LUMO levels of the adjacent organic photosensitive material.”

The unsupported extrinsic evidence offered by the Examiner does not “make clear the missing descriptive matter” that would justify a conclusion that the layer of quinacridone in Example 5 acts as an exciton blocking layer. Neither would such missing descriptive matter be recognized by one skilled in the art. Yoshikawa et al. teaches nothing about the importance of relative HOMO and LUMO levels and LUMO-HOMO energy gaps. Yoshikawa et al. does not teach that a more efficient device is achieved when the second acceptor layer has a LUMO-HOMO energy gap substantially larger than that of the first acceptor layer nor does the reference even mention any organic material energy gaps. Rather, the reference teaches that the second layer be “made of a material different than that of” the first, meaning that “the absorption wavelength region of layer b does not completely overlap with that of layer c.” Col. 5, lines 52-55. The focus of Yoshikawa et al. is not on energy gap at all, but on increasing the absorption range of the device. Therefore, from the description that “[i]t is preferable that the difference between the wavelengths of the absorption peaks for layer b and for layer c is not less than 20 nm,” (col. 5, lines 56-58), the first acceptor could have a higher energy gap than the second, in contradiction with the present invention. In addition, not only is there no teaching that the energy gap of the second layer must be greater than the first, there is also no suggestion that the energy gap of the second be *substantially* larger than the first layer. Finally, the second layer is not necessarily of sufficient thickness to prevent the diffusion of excitons from the first acceptor layer into or across the second layer. Therefore, the Examiner has not shown that the inclusion of an EBL in accordance with the device structure of the present invention “necessarily flows from the teachings of” Yoshikawa et al.

In summary, “[i]nherency ... may not be established by probabilities or possibilities. The mere fact that a certain thing may result from a given set of circumstances is not sufficient.” *In re Robertson*, 169 F.3d 743, 745 (Fed. Cir. 1999); *see also* MPEP §2112. Therefore, even if an exciton blocking layer did coincidentally “result from a given set of

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circumstances" in Yoshikawa et al., this is not a sufficient condition for anticipation by inherency. Rather, "the allegedly inherent characteristic [must] necessarily [flow] from the teachings of the applied prior art." Since this requirement has not been met, Applicants respectfully submit that neither Yoshikawa et al. nor Suzuki et al. inherently anticipate the present invention.

Attached hereto is a marked-up version of the changes made to the specification and claims by the current Amendment. The attached page is captioned "**Version with markings to show changes made.**"

In view of the foregoing Amendment and Remarks, the Applicants respectfully submit that all of the pending claims of the subject application are now in condition for allowance. Prompt reconsideration and allowance of the present application are therefore earnestly solicited.

Respectfully submitted,
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VERSION WITH MARKINGS TO SHOW CHANGES MADE

In the Specification:

The first full paragraph on page 30 has been amended as follows:

Alternatively, it is apparent from measurements of η_{INT} that an increased η_p can be achieved in a concentrator configuration where photons are forced to make multiple passes through the thin absorbing region. It should be appreciated regarding embodiment 1000 that light incident on a transparent face of the device can generally be reflected once off of an opposite interior reflecting layer and then either absorbed or possibly transmitted back out of the device. Device configurations are described in co-pending U.S. patent application No. 09/449,800 ~~Attorney docket number 10644/50501~~ (“~~50501~~ ‘800 Application”) (incorporated herein by reference) which cause any light admitted to a device to be reflected multiple times to increase absorption efficiency.

In the Claims:

1. (amended) An organic photosensitive optoelectronic device comprising:
 - two electrodes in superposed relation;
 - a hole transport layer between the two electrodes, the hole transport layer formed of a first photoconductive organic semiconductor material;
 - an electron transport layer between the two electrodes and adjacent to the hole transport layer, the electron transport layer formed of a second photoconductive organic semiconductor material; and
 - at least one exciton blocking layer between the two electrodes and adjacent to at least one of the two electrodes.

5. (amended) The device of claim 1 wherein the first photoconductive organic semiconductor material and the second photoconductive organic semiconductor material are selected to have ~~substantial~~ spectral sensitivity in the visible spectrum.

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6. (amended) The device of claim 2 wherein:

the electron transport layer is ~~PTCBI~~ 3,4,9,10-perylenetetracarboxylic-bis-benzimidazole (PTCBI);

the hole transport layer is ~~CuPe~~ copper phthalocyanine (CuPc); and

the exciton blocking layer is ~~BCP~~ 2,9-dimethyl-4,7-diphenyl-1,10-phenanthroline (BCP).

7. (amended) The device of claim 3 wherein:

the electron transport layer is ~~PTCBI~~ 3,4,9,10-perylenetetracarboxylic-bis-benzimidazole (PTCBI);

the hole transport layer is ~~CuPe~~ copper phthalocyanine (CuPc); and

the exciton blocking layer is ~~one of~~ selected from the group consisting of ~~m-MTDATA~~ 4,4',4''-tris{N, -(3-methylphenyl)-N-phenylamino}triphenylamine (m-MTDATA) ~~or PEDOT and~~ polyethylene dioxythiophene (PEDOT).

8. (amended) The device of claim 1 wherein the electron transport layer, the hole transport layer, and the at least one exciton blocking layer are disposed between two parallel planar reflective surfaces which form a waveguide.

11. (amended) A stacked organic photosensitive optoelectronic device comprised of a plurality of photosensitive optoelectronic subcells wherein at least one subcell ~~includes an exciton blocking layer~~ comprises:

two electrodes in superposed relation;

a hole transport layer between the two electrodes, the hole transport layer formed of a first photoconductive organic semiconductor material;

an electron transport layer between the two electrodes and adjacent to the hole transport layer, the electron transport layer formed of a second photoconductive organic semiconductor material; and

at least one exciton blocking layer between the two electrodes and adjacent to

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at least one of the two electrodes.

12. (amended) The device of claim ~~10~~ 11 wherein the ~~subcell including an exciton blocking layer has an~~ electron transport layer ~~including~~ includes PTCBI 3,4,9,10-perylenetetracarboxylic-bis-benzimidazole (PTCBI) and ~~a~~ the hole transport layer adjacent the electron transport layer and ~~including CuPe~~ includes copper phthalocyanine (CuPc).

13. (amended) The device of claim 11 wherein the at least one exciton blocking layer ~~subcell including an exciton blocking layer,~~ the exciton blocking layer includes BCP 2,9-dimethyl-4,7-diphenyl-1,10-phenanthroline (BCP) and is adjacent between the electron transport layer and ~~in spaced opposition to the hole transport layer~~ the electrode adjacent the at least one exciton blocking layer.

14. (amended) The device of claim 11 ~~where, in~~ wherein the at least one ~~subcell including an exciton blocking layer,~~ the exciton blocking layer is selected from the group consisting of ~~m-MTDATA~~ 4,4',4''-tris{N, -(3-methylphenyl)-N-phenylamino} triphenylamine (m-MTDATA) or ~~PEDOT~~ and polyethylene dioxythiophene (PEDOT), and is between ~~adjacent~~ the hole transport layer and ~~in spaced opposition to the electron transport layer~~ the electrode adjacent the at least one exciton blocking layer.

15. (amended) An organic photodetector comprising:

- a cathode and an anode in superposed relation;
- a plurality of pairs of a hole transporting layer adjacent to an electron transporting layer, the pairs disposed between the cathode and the anode; and
- an exciton blocking layer disposed between one of the cathode and the anode, and the plurality of pairs.

16. (amended) The ~~device~~ photodetector of claim ~~14~~ 15 wherein ~~one~~ the exciton blocking layer is disposed between the anode and the plurality of pairs.

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17. (amended) The ~~device~~ photodetector of claim ~~14~~ 15 wherein ~~one~~ the exciton blocking layer is disposed between the cathode and the plurality of pairs.

18. (amended) The ~~device~~ photodetector of claim ~~14~~ 15 wherein the exciton blocking layer comprises ~~is~~ BCP 2,9-dimethyl-4,7-diphenyl-1,10-phenanthroline (BCP).

19. (amended) The ~~device~~ photodetector of claim ~~14~~ 15 wherein the exciton blocking layer is selected from the group consisting of ~~m-MTDATA~~ 4,4',4''-tris{N, -(3-methylphenyl)-N-phenylamino}triphenylamine (m-MTDATA) ~~or PEDOT~~ and polyethylene dioxythiophene (PEDOT).

20. (amended) The ~~device~~ photodetector of claim ~~12~~ 15 wherein the hole transporting layers and the electron transporting layers of the plurality of pairs are selected to have ~~substantial~~ spectral sensitivity in the visible spectrum.

21. (amended) The ~~device~~ photodetector of claim ~~12~~ 15 wherein each ~~pair of the plurality of pairs are~~ CuPc ~~hole transporting layer comprises copper phthalocyanine (CuPc) and PTCBI~~ each electron transporting layer comprises 3,4,9,10-perylenetetracarboxylic-bis-benzimidazole (PTCBI).

22. (amended) The ~~device~~ photodetector of claim ~~12~~ 15 wherein the plurality of pairs is at least 5 pairs.

23. (amended) The ~~device~~ photodetector of claim ~~12~~ 15 wherein the plurality of pairs is at least 10 pairs.

24. (amended) The ~~device~~ photodetector of claim ~~12~~ 15 wherein ~~an~~ the exciton blocking layer is disposed between the anode and the plurality of pairs and a second exciton blocking layer is disposed between the cathode and the plurality of pairs.

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25. (new) An organic photosensitive optoelectronic device comprising:

two electrodes in superposed relation;

a hole transport layer between the two electrodes, the hole transport layer formed of a first photoconductive organic semiconductor material;

an electron transport layer between the two electrodes and adjacent to the hole transport layer, the electron transport layer formed of a second photoconductive organic semiconductor material; and

at least one exciton blocking layer between the two electrodes and adjacent to at least one of the two electrodes, wherein the thickness of the at least one exciton blocking layer is on the order of, or less than the exciton diffusion length.

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